DIVIMP simulation of W transport in JET H-mode plasmas

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INTRODUCTION

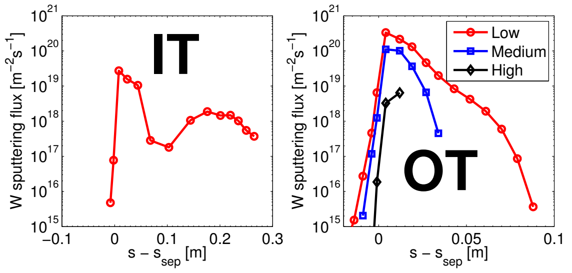
•Prediction of **tungsten contamination** in the inter-ELM phase of a high-triangularity, ITER-like wall reference plasma in JET: JPN *76666*, $B_t = 2.7$ T, $I_p = 2.5$ MA, $P_{in} \sim 16$ MW, $\delta \sim 0.4$ [1].

• Contamination predicted for **three** upstream densities:
Low ($n_{e\ sep,\ omp}$ = 1.9*10^{19}/m^3), Medium ($n_{e\ sep,\ omp}$ = 3.4*10^{19}/m^3), and High ($n_{e\ sep,\ omp}$ = 3.6*10^{19}/m^3).

•D+C background plasmas from 2-D fluid code EDGE2D/EIRENE [2].

• Calculations performed with the Monte Carlo trace-impurity code DIVIMP assuming W sputtering due to 1% C^{4+} in plasma

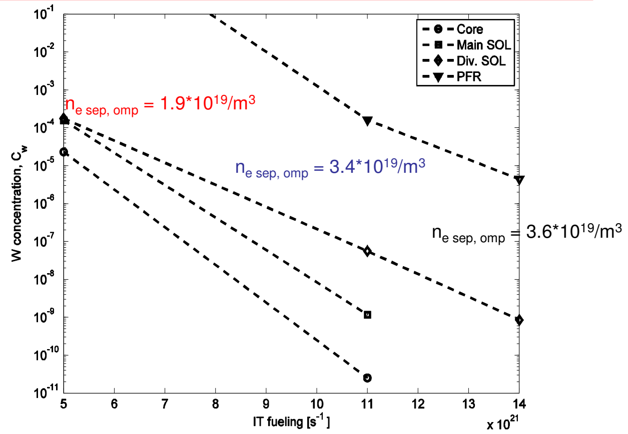
TUNGSTEN SOURCE IS DOMINATED BY SPUTTERING AT THE OUTER PLATE



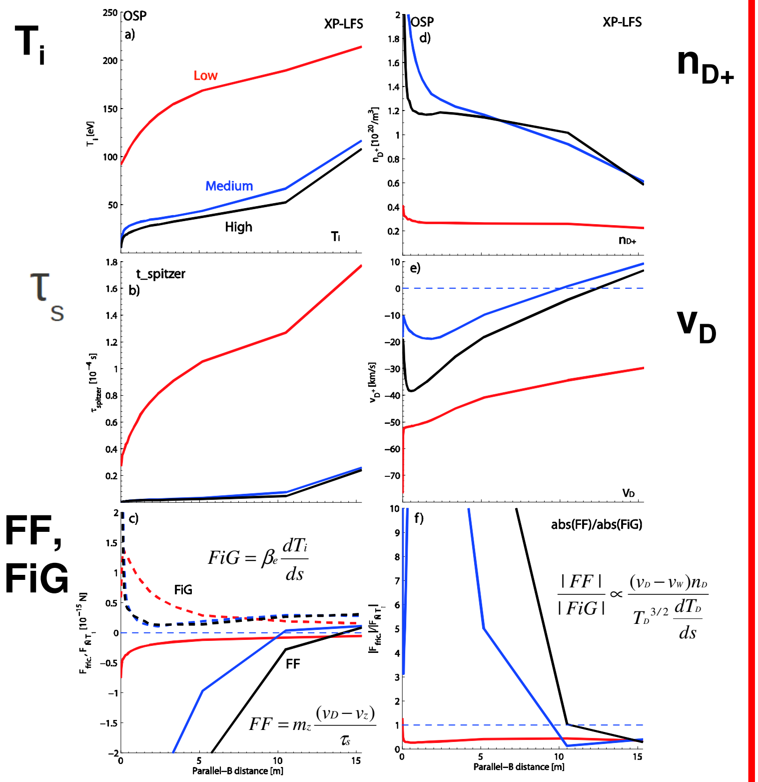
Case	Peak T_e [eV]	Plasma regime at OSP	Total W erosion rate I_W
Low	107	Sheath-limited	1.4*10^{20}/s
Medium	9	High-recycling	3.3*10^{19}/s
High	4	High-recycling	1.2*10^{18}/s

- Low ⇒ Medium density: I_W reduced by a factor of 4
- Medium ⇒ High density: I_W reduced by 1 order of magnitude

IN LOW DENSITY PLASMA, TUNGSTEN CONCENTRATION, $c_{W,}$ IS ABOVE 10^{-5} ON THE ENTIRE COMPUTATIONAL DOMAIN ⇒ c_W in core drops below 10^{-7} with increasing density



TUNGSTEN LEAKAGE IS SIGNIFICANTLY REDUCED, DUE TO INCREASED COLLISIONALITY, WITH INCREASING DENSITY



$$F_z = -\frac{1}{n_z}\frac{dp_z}{ds} + \underbrace{\boxed{m_z \frac{(v_D - v_z)}{\tau_s}}}_{F_{friction}} + ZeE + \alpha_e \frac{dT_e}{ds} + \underbrace{\boxed{\beta_e \frac{dT_i}{ds}}}_{F_{\nabla Ti}} \quad [4]$$

Low ⇒ Medium and high-density:

- ***T_i*** reduced by a factor of 3 – 4
- ***$\nabla T_{i,||}$*** increases near the plate, but becomes shallower along most of the divertor plasma ⇒ **$F_{\nabla Ti,||}$** reduces
- ***n_{D+}*** reduced by a factor of 4
 ⇒ Spitzer stopping time ***$\tau_s \propto T^{3/2} n_D^{-1}$*** reduced by 1.5 ord.s of magn.

•***v_D*** reduced near the plate by a factor of 2 – 5.
•Increased collisionality dominates over reduced flow velocity ⇒ **$F_{friction}$** increases
• |**FF**|/|**FiG**| ratio increases above unity ⇒ reduced leakage

CONCLUSION

•The low density plasma leads to core tungsten concentration of the order 10^{-5}
• The medium and high-density plasmas lead to sufficient divertor retention to ensure acceptable tungsten core concentration below 10^{-5}.
•Sufficient divertor retention is achieved with peak target *Te* below 10 eV.
•To achieve significant reduction of tungsten sputtering by multiple charged impurity species (e.g., Be^{2+}, C^{4+}), a peak target *Te* below 5 eV is required.

REFERENCES

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